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Failure of a bus hoisting platform due to unexpected system behaviour

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ABSTRACT

A bus hoisting platform showed an unexpected behaviour under asymmetric loading. In order to assess the internal restraints and joint forces which had not been considered properly in initial design, a numerical approach was chosen. With a multi-body simulation tool, the loads were calculated for different system configurations and loading situations. The identified loads were used for the stress analysis of individual components (analytical and numerical with FEM). The results revealed joint forces of a higher order than the total external load, which was a consequence of first the underestimated internal loads due to unapparent horizontal force components in the statically indeterminate system, and second, the implemented force control of the hydraulic actuators working in parallel. The correctly identified high internal loads explained the peculiar observations and lead to an insufficient fatigue strength of the welded structure.

1. Introduction

Bus hoisting platforms are an essential medium for the maintenance of vehicles in the public transport. There are several operating principles on the market, such as individual vertically acting (hydraulic) actuators, requiring a sophisticated control system. Shorter platforms are often supported by a scissors like mechanism. For longer vehicles like trucks including trailers or buses (also articulated buses), the most common principle consists in two or more parallel levers acting simultaneously on one single track of the hosting platform, or on the entire platform. This results in an additional longitudinal translation of the track when the platform is elevated. Depending on the working principle and on the placement of the actuators, the load sharing between the components and consequently the internal restraints can change severely.

A bus lift installed in a public transport corporation in Switzerland showed different inexplicable phenomena such as large deformations and clicking noise shortly after it had been put into operation. A safe operation was obviously not guaranteed and even a collapse had to be suspected. Therefore, the reasons for the unexpected behaviour had to be investigated, the risk of all uncertain consequences had to be assessed, and finally an evaluation had to be made if the equipment can be reconstructed for a safe operation.

The fatigue endurable design of such hoisting platforms (in the following simply called 'bus lifts') and their safe operation are governed in Europe by the standard SN EN 1493 [1]. The code allows the analytical estimation of the maximum expected service loads which was done for the original dimensioning of the present mechanism, but the wide range of possible loads and loading situations (vehicle and hoist position) implies a high risk of not detecting the most severe conditions. Furthermore, the additional complexity due to the statical indeterminacy of the mechanism requested an in-depth numerical analysis of the present bus lift. Thus the system was examined in the present study by means of a multi-body simulation (MBS) program for an exact prediction of the most severe operating condition. The resulting joint forces were taken as input for

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